The Hobby-Eberly Telescope Dark Energy Experiment (HETDEX)

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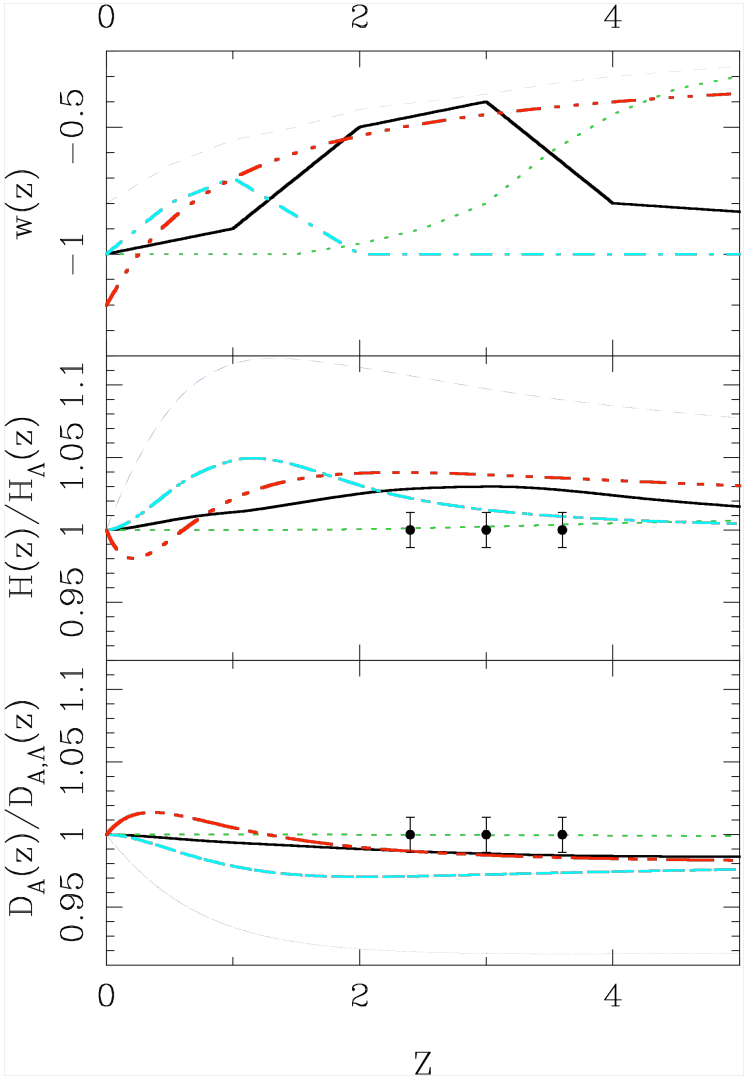
Goals for HETDEX

- HETDEX measures redshifts for about 1 million objects from 2<z<4
- Baryonic oscillations determine H and Da to 1% and 1.4% in 3 bins
- Constraints on constant w to about one percent
- Tightest constraints on evolving w at z=0.4 (to a few percent)

The issues are:

- measurements of H, Da, and redshift range
- and then going from H, Da to w

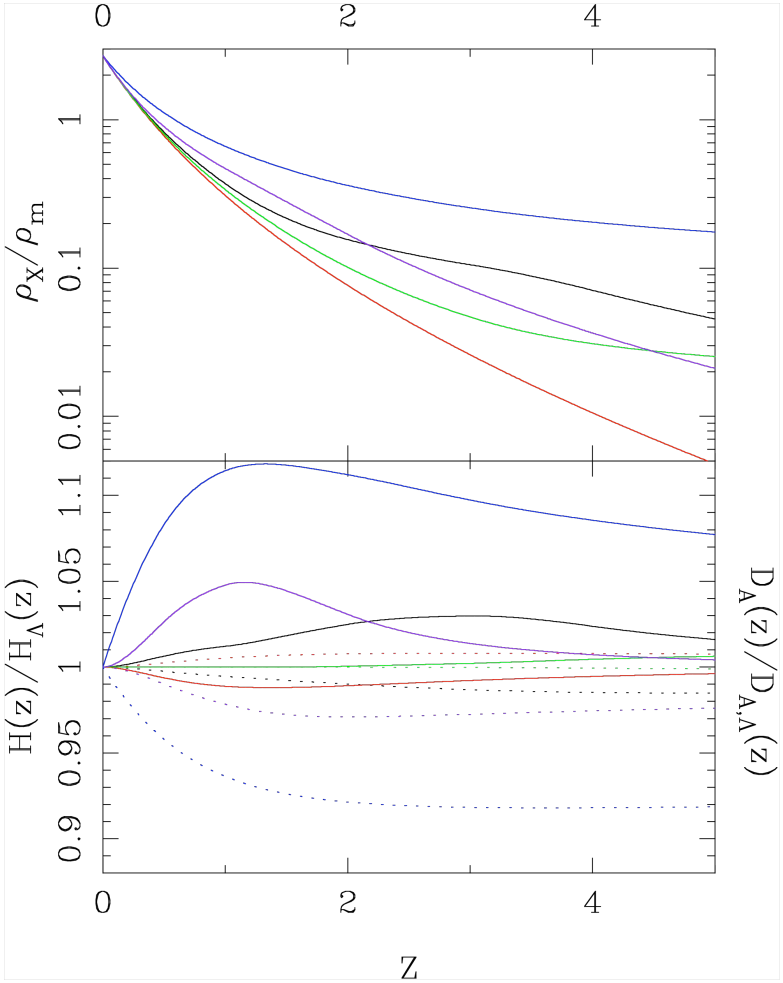
H(z), Da(z), and w(z)

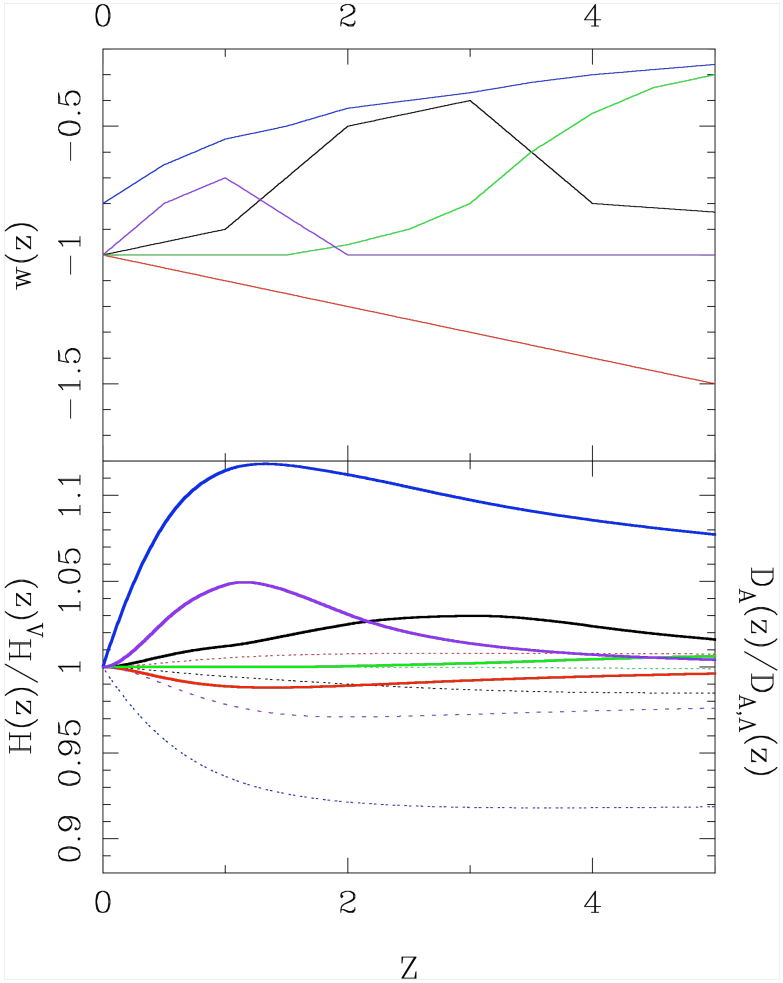


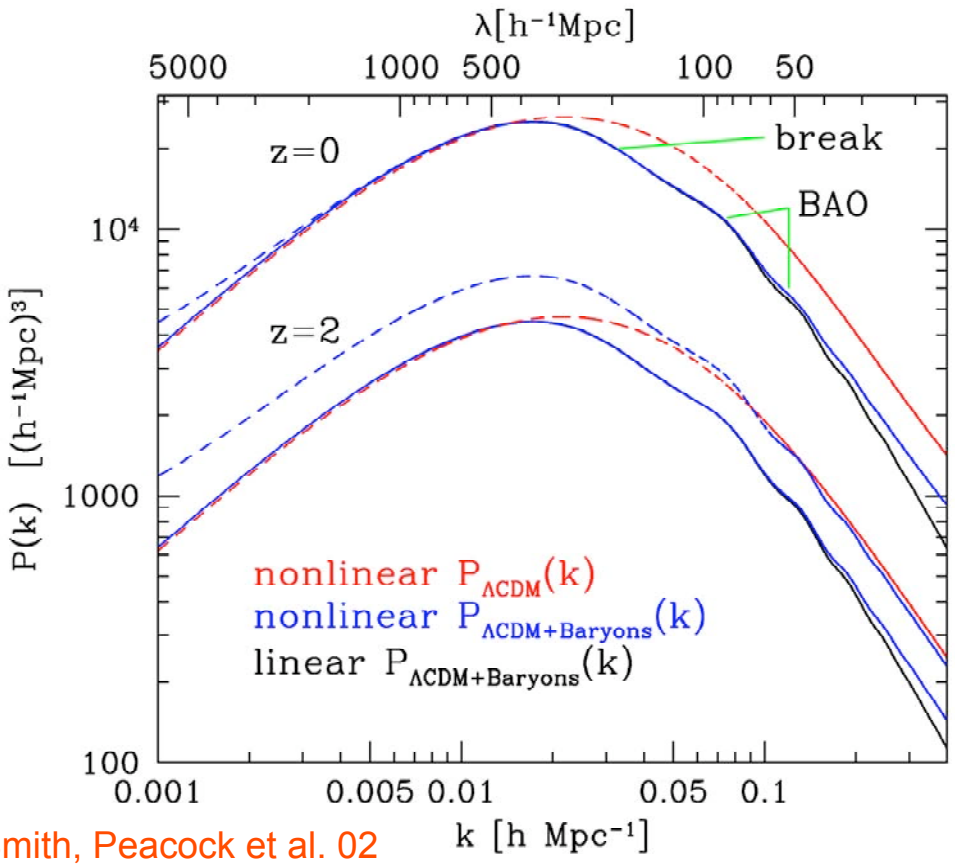
$$H(z) = h\sqrt{\Omega_m(1+z)^3 + \Omega_X \exp\left[3\int_0^z \frac{1+w(z)}{1+z}dz\right]}$$

The integral dependence of H on w allows low-z constraints from high-z observations

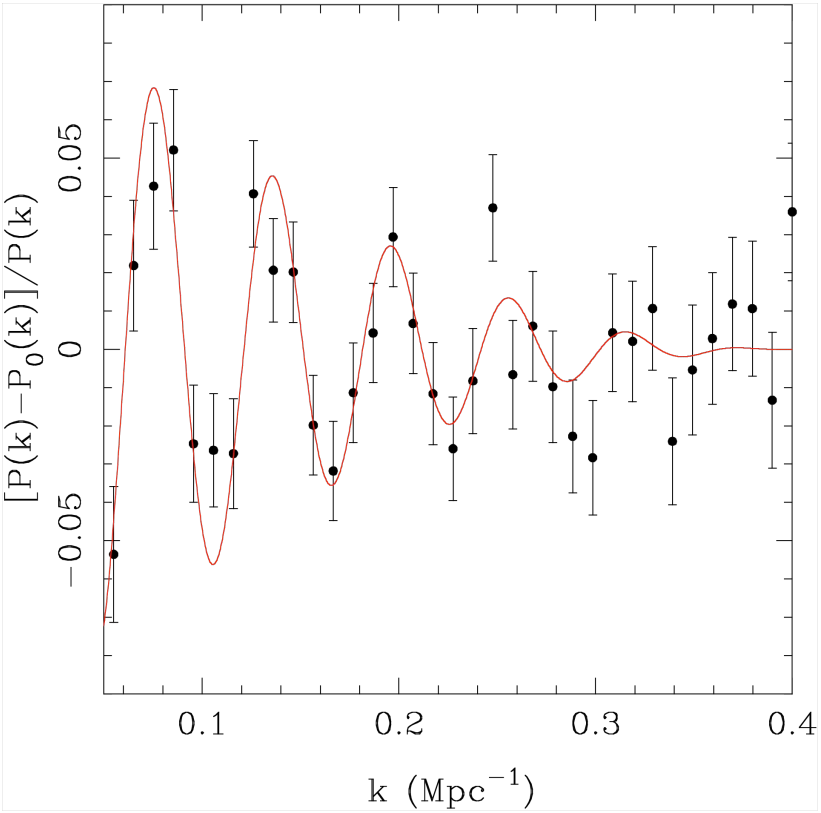
The need for accuracy vs. z





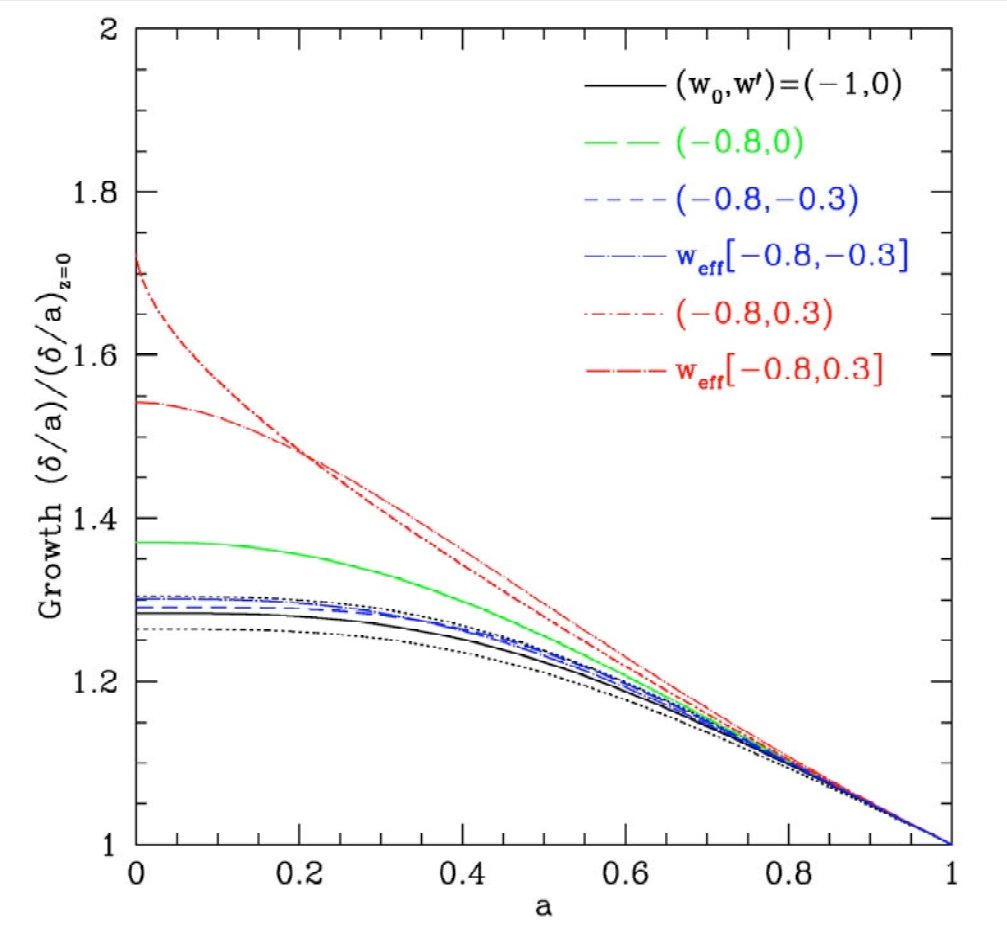


Smith, Peacock et al. 02



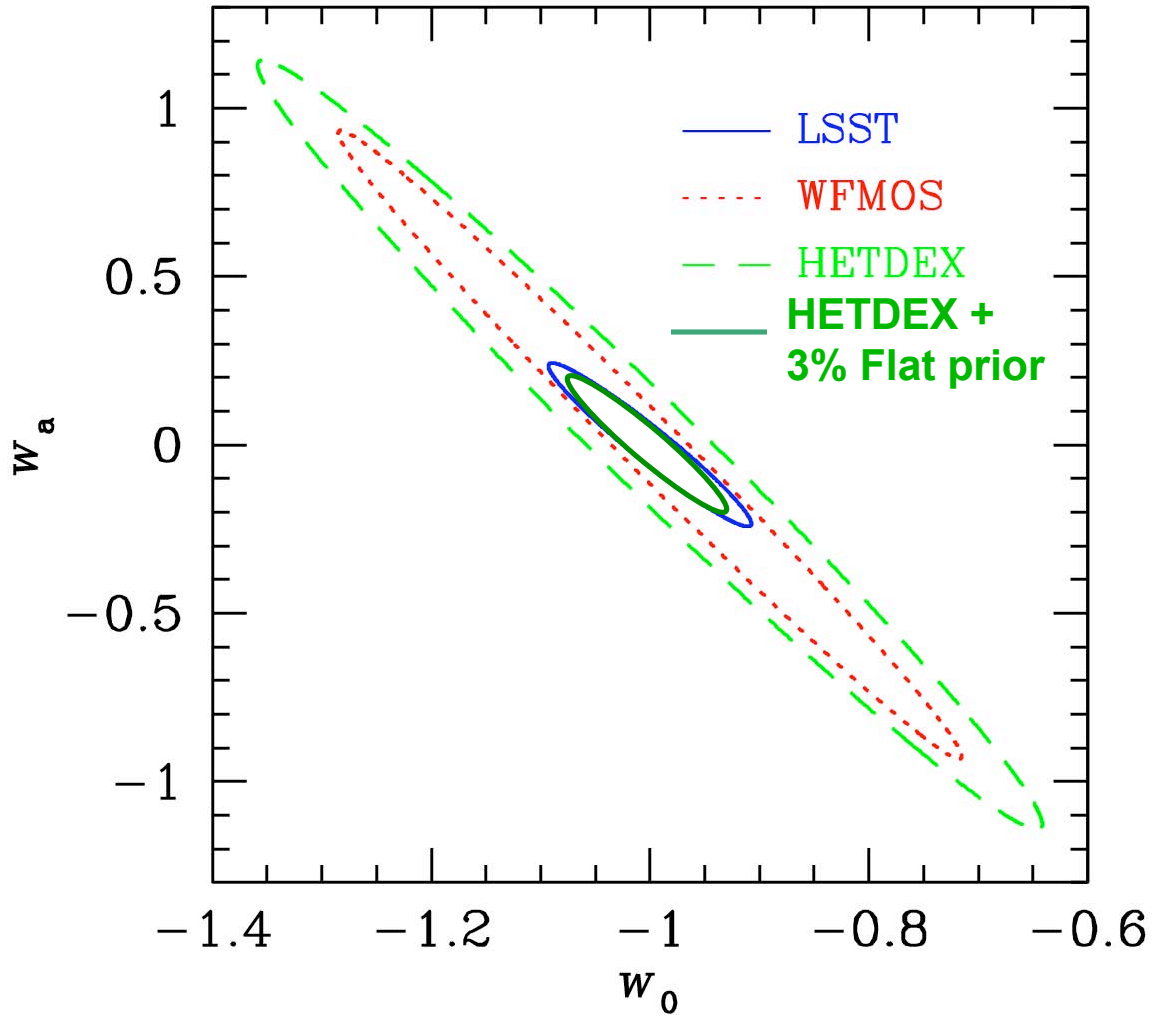
Power spectra analysis has 5 measures to exploit:

1. Phases of the oscillations (only one used now): geometric
2. Amplitude of oscillations: structure growth
3. Amplitude of P(k): structure growth
4. Linear/non-linear transition: geometric
5. Turn-over transition: geometric



- **Linder & Jenkins show the change in growth rate versus redshift.**
- **HETDEX is at a=0.25, where the effect is very strong (from z=0)**
- **WL growth estimates measures only integrated effect of g(z), whereas HETDEX measures it a particular z (evolution of w)**
- **HETDEX will get P(k) normalization to <1%, and g(z) to 2%**

Comparison of various DE projects (for w=w0+wa[1-a])
Curvature assumption is very important for HETDEX (high-z)



Systematics, Systematics, Systematics

• Koehler, Schuecker, Gebhardt (2006) show the power of BAO using an essentially assumption-free approach

• No other technique can compare with BAO in terms of understanding systematics: SN are problematic at the few percent level, CL needs mass estimates to 5%, WL who knows?

• A great advantage is that the accuracies predicted from BAO are very well understood: ratio of optimistic to pessimistic is 1.05 for BAO, 1.8 for SN, 2.0 for CL, over 6 for WL

• Thus, we can confidently predict what it will take to reach 3x and 10x current accuracies.

Advantages of HETDEX are:

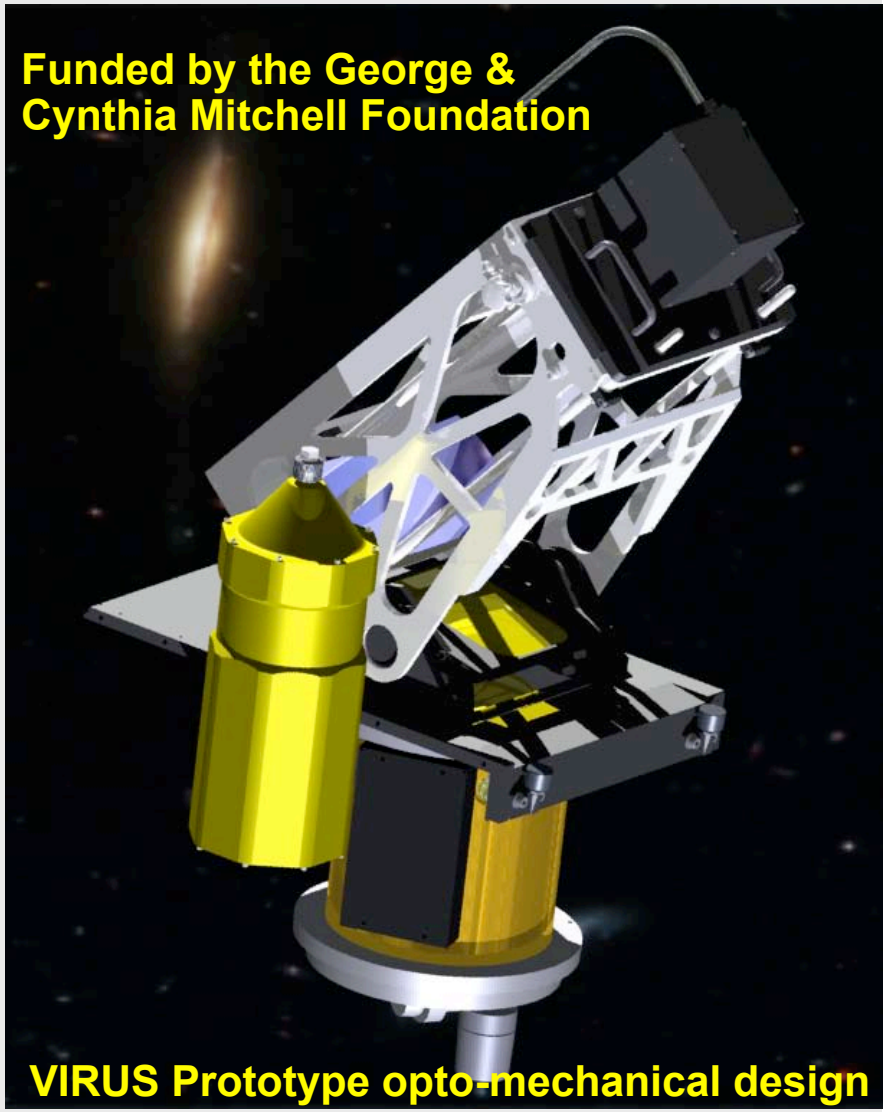
- **fastest Stage III program (needed for Stage IV planning)**
- **lowest systematics, because of BAO and high-z**
- **only experiment with constraints on early-time evolution, both from high-z estimate of distance and structure growth**
- **can be designed in phases**

HETDEX experimental requirements

- **A LAE DE survey reaching 1% precision requires the following**
  - **large volume to average over cosmic variance**
    - » **200-500 sq. degrees and $\Delta z \sim 2$**
    - » **this is 6-15 Gpc^3 at z~2-4**
  - **~ 1 million galaxies tracing LSS in the volume**
    - » **surface density ~3000 per sq. degree per $\Delta z=1$**
    - » **LAEs have 18,000 /sq. deg./$\Delta z=1$ at line flux ~1e-17 erg/cm2/s**
  - **lowest possible minimum redshift (bluest wavelength coverage)**
    - » **z = 1.8 at λ3400 A is a practical limit**
    - » **ties in well with high redshift limit of SNAP and other experiments**
- **These requirements can be met by a wide field IFU spectrograph**
  - **IFS obtains a spectrum of all spatial elements in the field of view, simultaneously**
  - **such an instrument is perfectly suited to the HET**

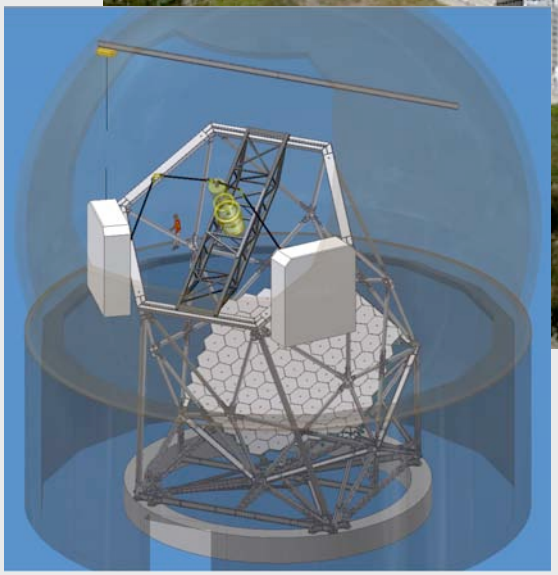
HETDEX technical requirements

- **V**isible **I**ntegral-field **R**eplicable **U**nit **S**pectrograph
  - Find LAEs and measure redshifts in one observation
- VIRUS is the prototype of the industrial replication concept
  - Each unit spectrograph is well within the state of the art
    - » each gives 0.25 sq. arcmin. and 340-570 nm wavelength range, R=850
  - ~145 VIRUS will cover
    - » 30 sq. arcminutes per observation
    - » Detect 14 million independent resolution elements per exposure
  - An order of magnitude more powerful than any existing spectrograph
- Prototype nearly ready for observing
  - Will be used for large pilot survey starting in November



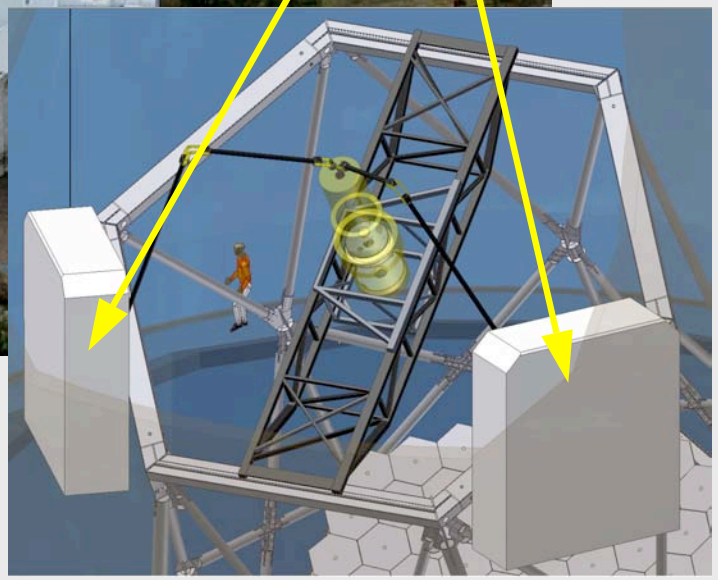
VIRUS on the HET

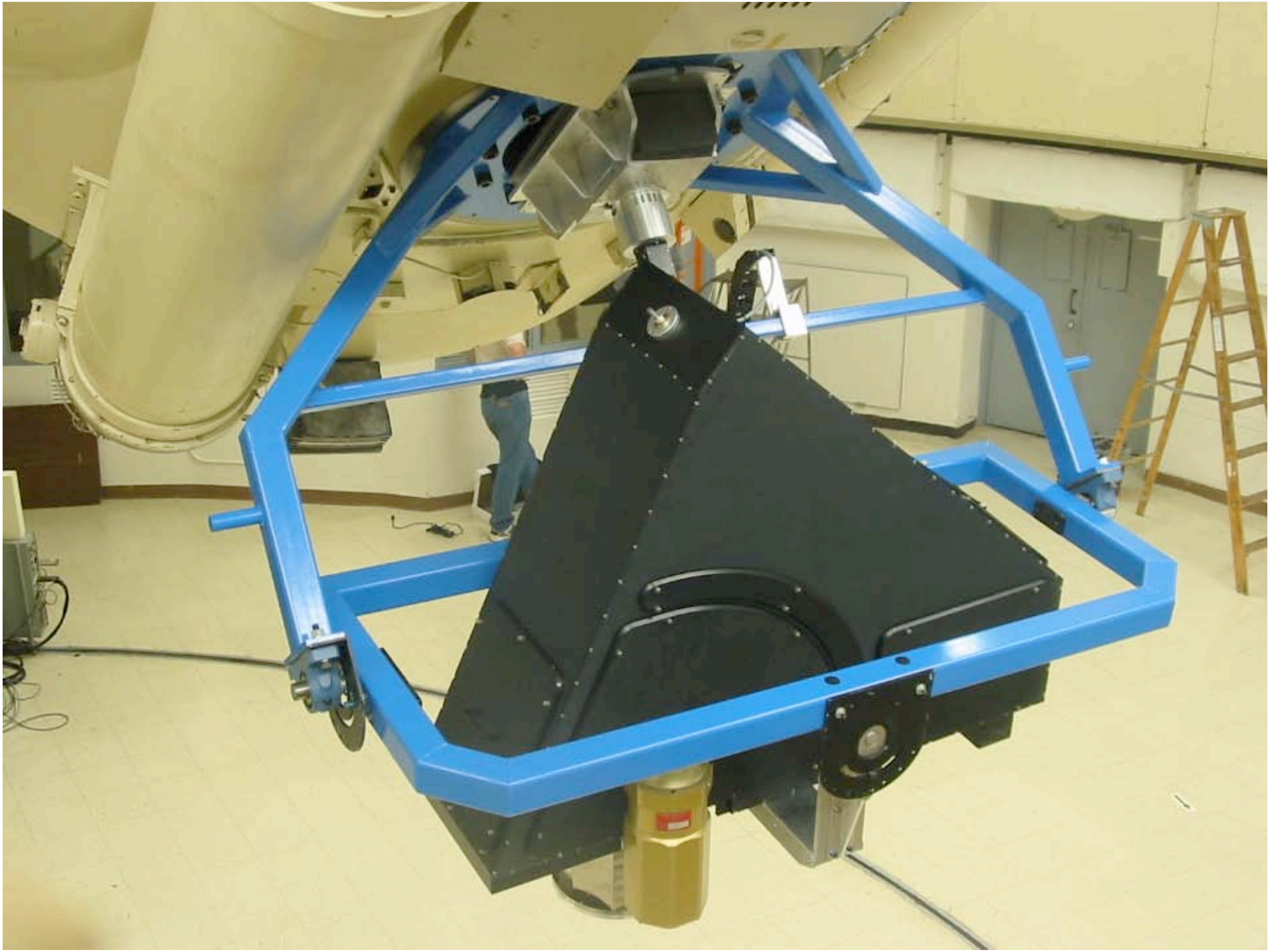
VIRUS consists of 145 units mounted on HET

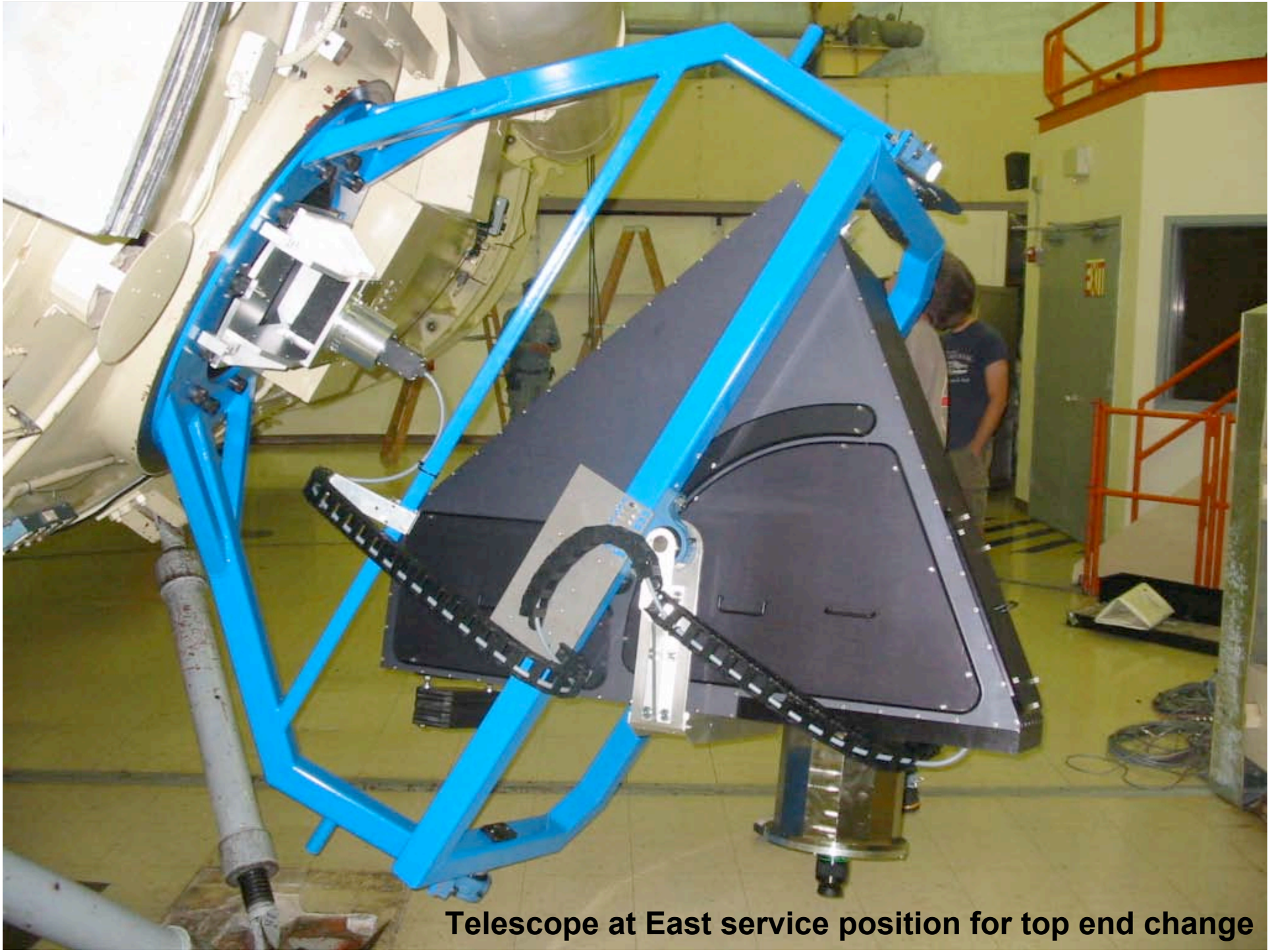


9.2 m HET
Mt. Fowlkes west Texas

New wide field corrector
New Tracker







Telescope at East service position for top end change

HETDEX Status

- **VIRUS-P pilot survey**
  - **to verify performance, test the engineering**
  - **to tell us the remaining information we need to plan HETDEX**
- Total cost ~$33M
  - **Upgrading HET to 22 arcminute diameter field of view**
  - **Building VIRUS**
  - **Observing and analyzing the data**
  - **~$15M raised and identified**
- **Timeframe is 3 years construction, 3 years observing**
  - **~100 clear dark nights**
  - **Completion in 2012/2013**

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